MINAR International Journal of Applied Sciences and Technology
ISSN: 2717-8234
Article type: Research Article

Received: 08/01/2023 **Accepted:** 01/02/2023 **Published:** 01/03/2023

DESIGN AND IMPLEMENTATION OF A HOT WATER HEATING SYSTEM

Saddi F RADHI [1]

Southern Technical University, Iraq

Yaareb M MATHBOOB [2]

Southern Technical University, Iraq

Malik R RSHIEH [3]

Southern Technical University, Iraq

Abstract:

The heating system in winter is very necessary, especially in cold areas, and there are several ways, including the use of fuel, and because of the increase in the use of fossil fuel energy and the high cost, and the risks of toxic gases resulting from fuel combustion, and this negatively affects human health. Where a heating system was designed based on the domestic heater instead of a boiler and the use of a radiator heat exchanger, a fan that enhances the air temperature distribution system in the room, and a water pump to push water into the system with an electronic control, a system equipped with digital sensors to measure the temperature. After operating the system, the temperature of the hot water ranged from 80°C to 90°C, and the atmosphere inside the test room ranged from 17°C, the finding are good from where of energy consumption and heating in a record time at an average of 25.8°C.

Keywords: Heating System, Energy Consumption, Heat Exchanger.

http://dx.doi.org/10.47832/2717-8234.14.9

[1] saadi.faisal@stu.edu.iq
[2] Yaareb.m.m@stu.edu.iq
[3] malik.rshieh@stu.edu.iq

1. INTRODUCTION

In the past decades, the theme of the exploitation of many efforts in the world to research cleaner air, and thus to limit the emissions of greenhouse gases. The use of fossil fuels has put a lot of pressure on the environment, therefore, scientists all over the world are looking for new environmentally friendly technologies that are suitable for the energy system, (Goričanec et al., 2020) ; (Zhuang et al., 2009). The effect of water heating during the maximum cost periods and changes in energy prices for each period must be analyzed. Electric water heaters, especially electric water heaters, due to their high efficiency, these systems are introduced to reduce energy costs (Hohne et.al., 2018). The buildings contain different types of movable goods that require different control strategies, such as heating and cooling the spaces, hot water, etc. The topic of several studies on energy flexibility in buildings, all of them focus on one or more of the above-mentioned building loads(Marszal-Pomianowska et al., 2016) ; (Peeters et al., 2008). The ability to adapt residential equipment to respond to heat demand using the data of an experimental test, it is possible to use hot water systems in the home in several thermal energy storage systems (Heier et al., 2015). The goal is to present a new point of view about the importance of water heating structures with electricity and respecting the environment and the economic savings that can be achieved (Joubert et al., 2016). The theme of implementation of the demand side management approach to control the heating of the room in the built environment through the use of energy efficiency technology: heat pump and heat storage for heating equipment. The explanation of the thermal response of the building with the electric heating system in the case of reference set in an ordinary residence in (UK), (Arteconi et al., 2013).

Nomenclature

A	Area (m^2)
CP	Specific heat capacity ($kJ/kg\ K$)
d	Diameter, (mm)
M	Mass of water (litter)
$\dot{m}$	Mass flow rate (kg/s)
T	Temperature (◦C)
U	Heat transfer coefficient ($kW/m^2\ K$)
v	Volume of water heater (m^3)

Greek symbols

ρ	Density, kg/m^3

Abbreviations

ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
HVAC	Heating ventilation and air conditioning

Reduce CO2 emissions can be reduced by up to 94%, resulting in better and higher energy performance ratings despite the required heat, savings are achieved in all the cases studied with a significant reduction in energy costs (Las-Heras-Casas, 2018). The best heating systems for residential buildings have an object heating temperature gap of 25-30°C in future district heating networks and the heating return temperature in the area can be in the reach of 30-40°C (Østergaard et al., 2021). Space heating connections are carried out and household hot water is prepared centrally in hot water tanks or heat exchange providing thermal comfort for space occupants as well as reducing energy consumption (Huang et al., 2020) ; (Averfalk, 2021). The first aim of this study was to describe the exploitation of the domestic heater for heating instead of fossil fuels or electricity, and one of its advantages is rapid heating, getting rid of moisture, high efficiency, economical and inexpensive, simplicity in installation and uncomplicated. The results of this study are as

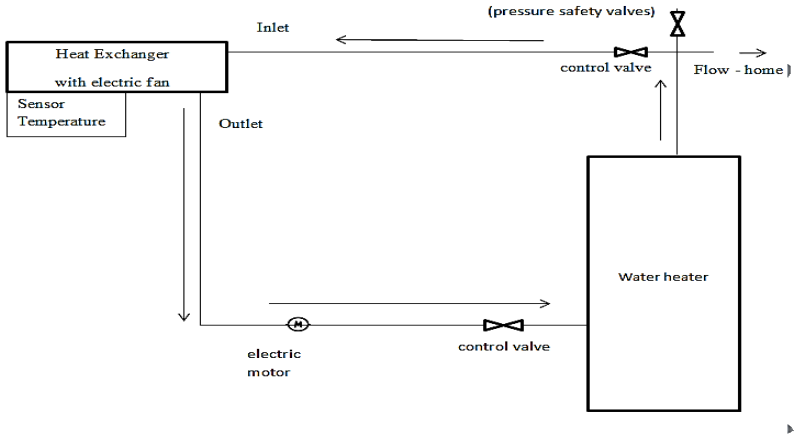
follows, the use of hot water from the domestic heater for the purpose of heating shows the lowest energy consumption and reduces dependence on fossil fuels.

2. SCOPE OF WORK

The heating system available in all countries is either heating with electrical appliances or by appliances that use fuel, and there are many problems in both cases, so we turned to the work of this system, which depends in its work on hot water supplied by the domestic heater and transferring water through pipes to the exchanger Thermal The internal part in the room (radiant) and after conducting the test in one of the houses in a room of dimensions (7 m x 4 m), the system was turned on and readings were taken at different times in the winter of 2022. Figure 1 shows an illustrative diagram of the designed and implementation heating system.

Figure 1

Schematic view of a hot water heating system

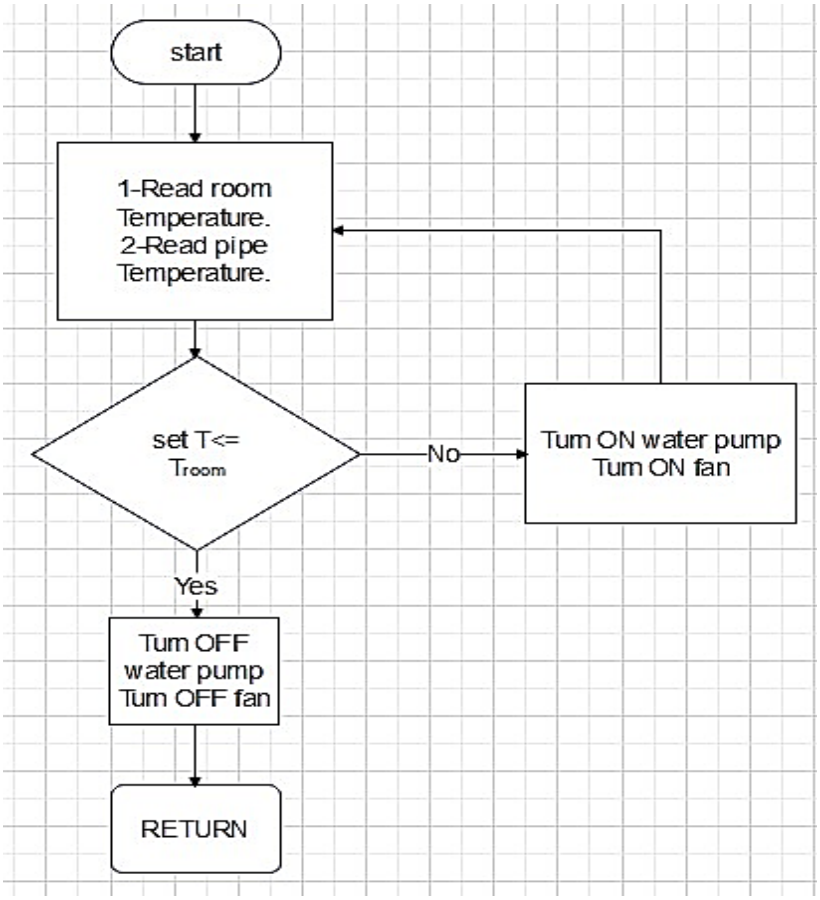


3. METHOD AND MATERIALS

The methodologies, which have been applied in this study, are as follows; design and implementation of a hot water heating system. Gathering ,data by doing measurements and field, study in the propose household to gather (room temperature, humidity and pipe temperature). A heating ventilation and air conditioning system (HVAC) consists, of many equipment and components, that are aranged in a sequential system to remove moisture, cool, purify, clean and transfer conditioned outside air and recirculated air to the conditioned space, and all measurements were made in the room. As well as the basic steps to perform design shown in Figure 2.

Figure 2

Flowchart of Methodology



3.1 Physical Parameters Measurement

Physical parameters measurment has been carried out in order to consider room temperature, pipe temperature and relative humidity. The measuring devices and materials used in this study are: Room thermo + hygrometer (FILIPS)، water heater thermometer، electric heater، heat exchanger (radiant) ،the liquid used is water، digital sensors، electric pump and copper connection tubes with a diameter of 5 mm. Figure 3 illustrate data collection for the implemented heating system.

Figure 3

Data collection for the implemented heating system

The heat exchanger system calculates the compressor, evaporator, and condenser performance iteratively using the air conditions as input, and supplies the compressor with the air-on temperature based on those air conditions. The experiment is then carried out using those air conditions. This experiment is continued، throughout the winter 2022. The room temperature is calculated from energy according to the following Equations, from (1)-(6).

$$Consumption\ energy, E = m * Cp * \Delta T \quad (1)$$

$$m = E/(Cp * \Delta T) \quad (2)$$

$$V = m / \rho = \pi * D2 / 4 * H \quad (3)$$

$$Q_{heating} = \dot{m}\, cp(T_{room} - T_{water\ heater}) \quad (4)$$

$$Q_{heating} = AU_{office}(T_{ambient} - T_{room}) \quad (5)$$

$$T_{room} = \frac{AUT_{ambient} + m\ cp\ T_{water\ heater} + Q_{load}}{m\ cp + AU} \quad (6)$$

4. RESULT AND DISCUSSION

4.1 ROOM TEMPERATURE

The heat source for the heating system is hot water from the domestic water heater, and after the test was conducted in one of the domestic houses, the system was turned on and readings were taken at different times in the winter season, The results obtained from this experiment on January 1, 2022, the room temperature before heating was (3 °C) and

the humidity was (53%). After nine minutes of turning on the heating system, the temperature stabilized, with an average (25.14 °C) and relative humidity (33.5%), which is a good result as shown in Tables 1.

Table 1.

Operation results of daytime stage operation

No	daytime stage operation	Time hr:min (am)	External Pipe Temperature °C	Room Temperature °C	Relative Humidity %
1	1/1/2022	11:48	71	23	34
2	1/1/2022	11:50	68.3	24	30
3	1/1/2022	11:52	57.2	25	30
4	1/1/2022	11:54	52.1	25	30
5	1/1/2022	11:56	50.6	26	30
6	1/1/2022	11:58	46.6	26	30
7	1/1/2022	11:59	46.3	27	29

Also the results obtained from this experiment on January 15, 2022, the room temperature before heating was (5 °C) and the humidity was (50%). After nine minutes of turning on the heating system, the temperature stabilized, with an average (26.8°C) and relative humidity (30%), which is a good result as shown in Tables 2.

Table 2.

Operation results of daytime stage operation

No	daytime stage operation	Time hr:min (am)	External Pipe Temperature °C	Room Temperature °C	Relative Humidity %
1	15/1/2022	11:48	71	20	34
2	15/1/2022	11:50	68.3	25	34
3	15/1/2022	11:52	60.4	25	33
4	15/1/2022	11:54	58	29	32
5	15/1/2022	11:56	53.1	29	32
6	15/1/2022	11:58	51.9	30	32
7	15/1/2022	11:59	46.6	30	31

However the results obtained from this experiment on February 1, 2022, the room temperature before heating was (10 °C) and the humidity was (50%). After nine minutes of turning on the heating system, the temperature stabilized, with an average (27.4°C) and relative humidity 32.4%, which is a good result as shown in Tables 3.

Table 3.

Operation results of daytime stage operation

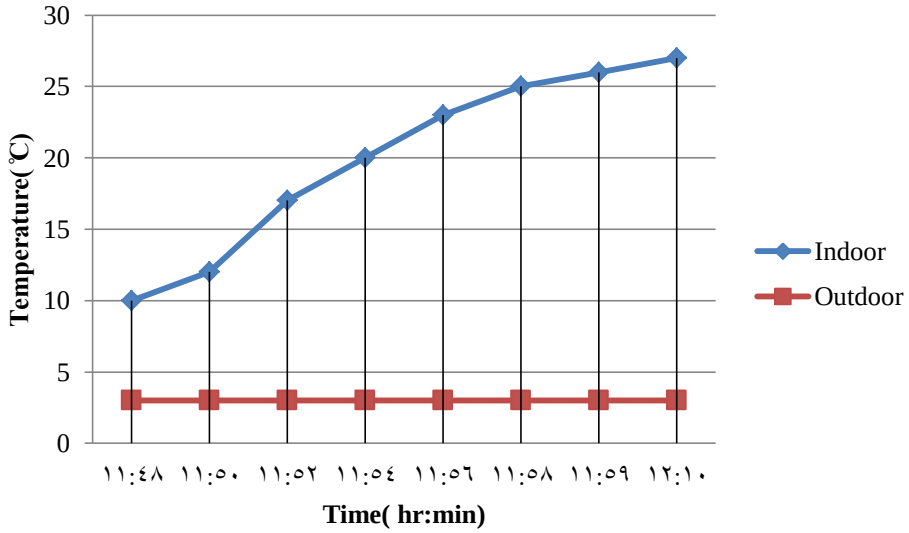
No	daytime stage operation	Time hr:min (am)	External Pipe Temperature °C	Room Temperature °C	Relative Humidity %
1	1/2/2022	11:48	70	22	46
2	1/2/2022	11:50	69.3	25	36
3	1/2/2022	11:52	66.8	26	32
4	1/2/2022	11:54	64	27	30
5	1/2/2022	11:56	64.2	29	30
6	1/2/2022	11:58	59.2	31	30
7	1/2/2022	11:59	55.1	32	30

4.2 INDOOR AND OUTDOOR TEMERATURES

The thermal properties of different temperatures of the designed air conditioner were studied and according to the results shown in Tables 1-3 the internal temperature was (25.8°C, 26.8°C, 27.4°C) and these results are within ASHRAE recommends. Where the indoor temperature was stable and almost constant after nine minutes of operating the heating system as illustrated in Figure 4, while the outside temperature, varies. The outside temperature fluctuated-around 3°C in the first test period, while it was 5°C in the second test period and finally recorded 10°C in the third test period.

Figure 4

Indoor and outdoor temperatures with turned on a heating system

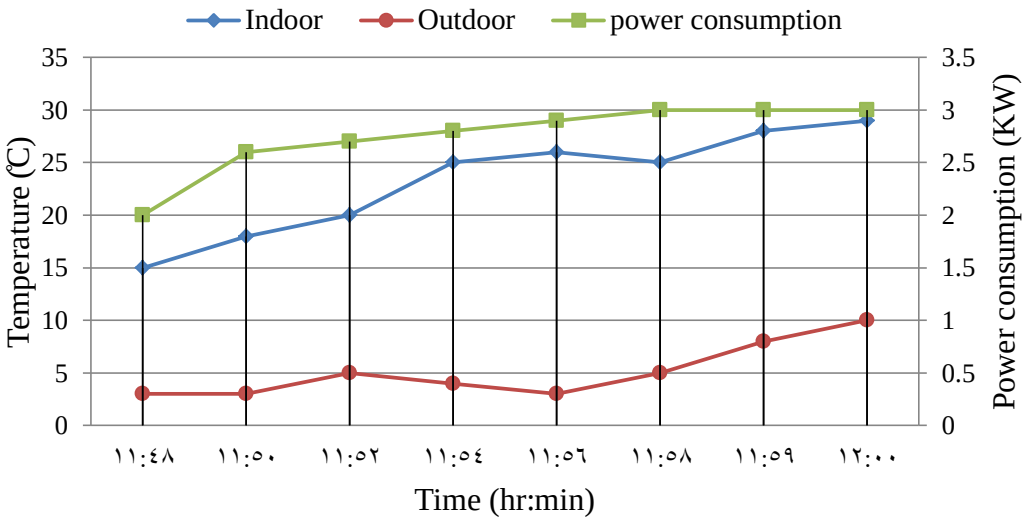


4.3 AIR CONDITIONER POWER CONSUMPTION

While the exterior temperature varied depending on the surrounding climate, the average inside temperature was maintained at 25.8°C. While the heating system cycled on and off to maintain a consistent interior temperature, Figure 5's variance of the air conditioner's power usage changed significantly. Hence, over a 24-hour period, the heating system's energy use averaged 3.5 kW.

Figure 5

"Indoor and outdoor temperatures with" power consumption



5. CONCLUSIONS

This study evaluated the implementation of the heating system for the winter of 2022, which depends in its work on hot water supplied from the domestic heater and transfer of water through pipes to the heat exchanger, and provides feedback for this design. The first goal was to describe the exploitation of the domestic heater for heating instead of fossil fuels or electricity, and one of its advantages is rapid heating, getting rid of moisture, high efficiency, economical and inexpensive, simplicity in installation and uncomplicated. The results of this study are as follows: The use of hot, water, from the domestic heater for the purpose of heating, shows the lowest energy consumption and reduces dependence on fossil fuels.

ACKNOWLEDGMENT

The authors, would like to thank Southern Technical University STU/Shatrah Technical Institute for supporting this research.

REFERENCES:

Arteconi, A., Hewitt, N. J., & Polonara, F. (2013). Domestic demand-side management (DSM): Role of heat pumps and thermal energy storage (TES) systems. *Applied thermal engineering*, *51*(1-2), 155-165.

Averfalk, H., Möllerström, E., & Ottermo, F. (2021). Domestic hot water design and flow measurements. *Energy Reports*, *7*, 304-310.

Goričanec, D., Ivanovski, I., Krope, J., & Urbancl, D. (2020). The exploitation of low-temperature hot water boiler sources with high-temperature heat pump integration. *Energies*, *13*(23), 6311.

Heier, J., Bales, C., & Martin, V. (2015). Combining thermal energy storage with buildings–a review. *Renewable and Sustainable Energy Reviews*, *42*, 1305-1325.

Hohne, P. A., Kusakana, K., & Numbi, B. P. (2018, April). Operation cost and energy usage minimization of a hybrid solar/electrical water heating system. In *2018 international conference on the domestic use of energy (DUE)* (pp. 1-7). IEEE.

Huang, T., Yang, X., & Svendsen, S. (2020). Multi-mode control method for the existing domestic hot water storage tanks with district heating supply. *Energy*, *191*, 116517.

Joubert, E. C., Hess, S., & Van Niekerk, J. L. (2016). Large-scale solar water heating in South Africa: Status, barriers and recommendations. *Renewable energy*, *97*, 809-822.

Las-Heras-Casas, J., López-Ochoa, L. M., Paredes-Sánchez, J. P., & López-González, L. M. (2018). Implementation of biomass boilers for heating and domestic hot water in multi-family buildings in Spain: Energy, environmental, and economic assessment. *Journal of Cleaner Production*, *176*, 590-603.

Marszal-Pomianowska, A., Heiselberg, P., & Larsen, O. K. (2016). Household electricity demand profiles–A high-resolution load model to facilitate modelling of energy flexible buildings. *Energy*, *103*, 487-501.

Østergaard, D. S., Tunzi, M., & Svendsen, S. (2021). What does a well-functioning heating system look like? Investigation of ten Danish buildings that utilize district heating efficiently. *Energy*, *227*, 120250.

Peeters, L., Van der Veken, J., Hens, H., Helsen, L., & D'haeseleer, W. (2008). Control of heating systems in residential buildings: Current practice. *Energy and Buildings*, *40*(8), 1446-1455.

Zhuang, Z., Li, Y., Chen, B., & Guo, J. (2009). Chinese kang as a domestic heating system in rural northern China—A review. *Energy and Buildings*, *41*(1), 111-119.